Space Weather Technical Forecast

Issued on Sunday, 02 June 2024 at 12:19 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Moderate to High solar activity with further M-class or X-class flares likely. Glancing CME impacts possible into the period with a chance of G1/G2 Minor or Moderate Geomagnetic Storms.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Remains High with a further X-class flare observed, X1.0 at 01/1836 UTC, and a long period M7.3 flare, peaking at 01/1940 UTC, both from AR3697 in the southeast disc. There are now eight numbered spots on the disc and one unnumbered, with a NEW region rounding the northeast limb. AR3697 in the southeast persists as the most notable spot, although recent weakening trends have continued as umbra within the main delta spot continue to fragmented somewhat. The next most complex groups are AR3699 and AR3700. Both are somewhat magnetically complex, the latter indicating ongoing growth and consolidation of its spots. Other regions on the disc are smaller, simpler and appear more stable at this time.

The X1.0 flare of AR3697 at 01/1836 UTC was followed by a sympathetic, long period M7.3 flare from the same region, peaking at 01/1940 UTC, with Type II and IV Radio Emissions observed with the second of these flares. A full-halo CME was observed from Earth's frame of reference around the time of the first flare but has been assessed as far-sided, with the second flare resulting in a smaller partial halo CME, potentially Earth-directed but apparently more displaced towards the south and east. Analysis of this second feature suggest the potential for a glancing impact sometime later on day 3 (04 Jun). No other Earth-directed CMEs observed in available imagery, although investigation continues into some EUV dimming observed around 02/0000 UTC in the northeast disk.

Solar Wind / Geomagnetic Activity: Observations by ACE at L1 showed speeds persisting at background at 310-360 km/s, with density largely below average. The Interplanetary Magnetic Field, Bt, was weak, 1-5nT with the north-south component, Bz, also varying weakly. Phi angle was generally negative (towards the Sun), briefly rotating to be slightly positive (away from the Sun) at times. Geomagnetic activity was Quiet (Kp 0-2).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux at GOES18 remained at background levels with no solar radiation storms occurring. High energy electron flux (greater than 2MeV) at GOES16 was at background to moderate levels with the associated 24-hour fluence well below the Active threshold. Observed fluence at 02/0000 UTC was 2.98e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: High to Moderate activity is forecast with further M-class expected and a chance of isolated or X-class flares, mainly from AR3697 in the southeast.

Solar Wind / Geomagnetic Activity: A weak CME from the C7.5 flare of AR3698 on 31 May is expected either late day 1 or early day 2 (02-03 Jun), although confidence is low with the

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strength of any arrival due to the faint and apparent weak nature of the CME. Analysis of a CME associated with the long period M7.3 flare from AR3697, peaking at 01/1940 UTC, suggest the potential for a glancing impact sometime later on day 3 (04 Jun). Otherwise largely background winds are likely to persist, with a chance of becoming slightly enhanced for a time between days 1 and 2 (02-03 Jun) with any onset of the fast wind of small CH41/+, however this is also low confidence.

Geomagnetic activity is forecast to be mainly Quiet initially, but perhaps increasing to give Unsettled to Active intervals with any fast wind onset days 1-2 (02-03 Jun) or weak CME arrival, with a slight chance of G1 Minor Storm intervals. The risk of Active conditions increases into day 3 (04 Jun), with an increased chance of G1-G2 Minor to Moderate Strom intervals associated with any CME arrival, this risk easing into day 4 (05 Jun).

Energetic Particles / Solar Radiation: High energy proton flux is expected to persist at background, but with a slight chance of rising above the S1/Minor Storm threshold given any further notable flares. High energy electron flux is forecast to persist at background, with the associated 24 hour fluence forecast to remain below the Active threshold.

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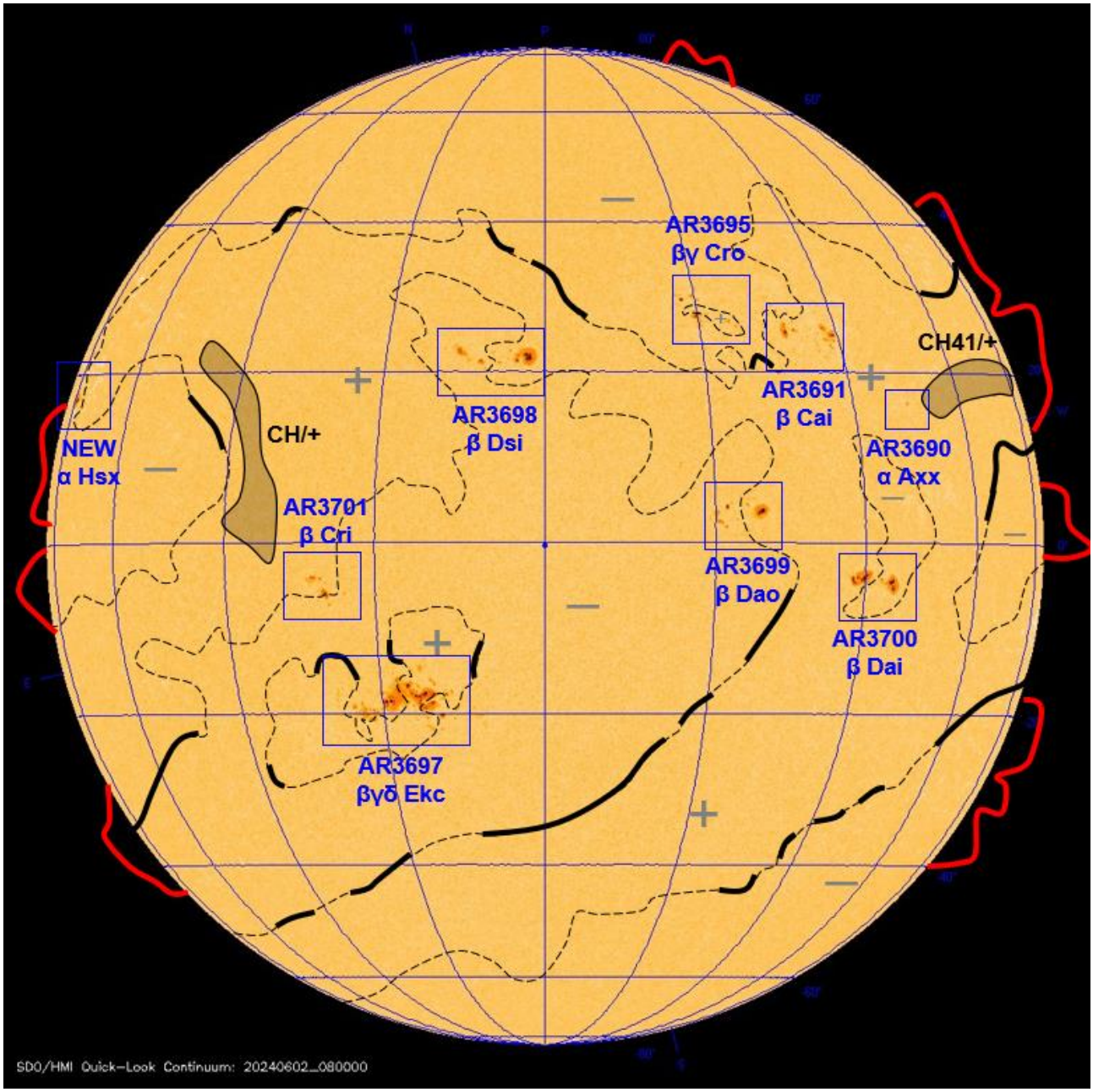
Figure 1. Solar Analysis Valid 02/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A faint partial halo CME was observed on 30 May, perhaps from the C7.5 flare of AR3698 and subsequent nearby coronal dimming around 30/0500 UTC. This is very low confidence, due to the indistinct nature of the CME on imagery, but brings the potential for a weak arrival late on day 1 or perhaps more likely early day 2 (02-03 Jun).

The X1.0 flare of AR3697 at 01/1836 UTC was followed by a sympathetic, long period M7.3 flare from the same region, peaking at 01/1940 UTC, with Type II and IV Radio Emissions observed with the second of these flares. A full-halo CME was observed from Earth's frame of reference around the time of the first flare but has been assessed as far-sided, with the second flare resulting in a smaller partial halo CME, potentially Earth-directed but apparently more displaced towards the south and east. Analysis of this second feature suggest the potential for a glancing impact sometime later on day 3 (04 Jun).

Current background solar winds may see a very weak enhancement from CH41/+ on day 1 (02 Jun), perhaps becoming slightly elevated before likely easing to background again during day 2 or 3 (03 or 04 Jun) in the absence of any CME enhancement. This feature is currently overestimated in current MOSWOC ENLIL output, leading to reduced confidence in any potential connection, but also in the arrival times of forecast Earth-directed CMEs. There are also a number of large filaments currently on the Earth-facing disc. These will be closely monitored for any potential Earth-directed eruptions should any of these features lift-off of the solar surface.

Geomagnetic activity is forecast to be mainly Quiet initially, but perhaps increasing to give Unsettled to Active intervals with any fast wind onset days 1-2 (02-03 Jun) or weak CME arrival, with a slight chance of G1 Minor Storm intervals. The risk of Active conditions increases into day 3 (04 Jun), with an increased chance of G1-G2 Minor to Moderate Strom intervals associated with any CME arrival, this risk easing into day 4 (05 Jun).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	20	50	20
Strong	G3	No	1	1	5	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
31/1205	Partial	C7.5 Flare	NE	710 km/s	03/0000 UTC +- 9hrs	Low confidence
02/0048	Partial	M7.3 Flare	SE	700 km/s	04/2100 UTC +-12hrs	Glancing blow

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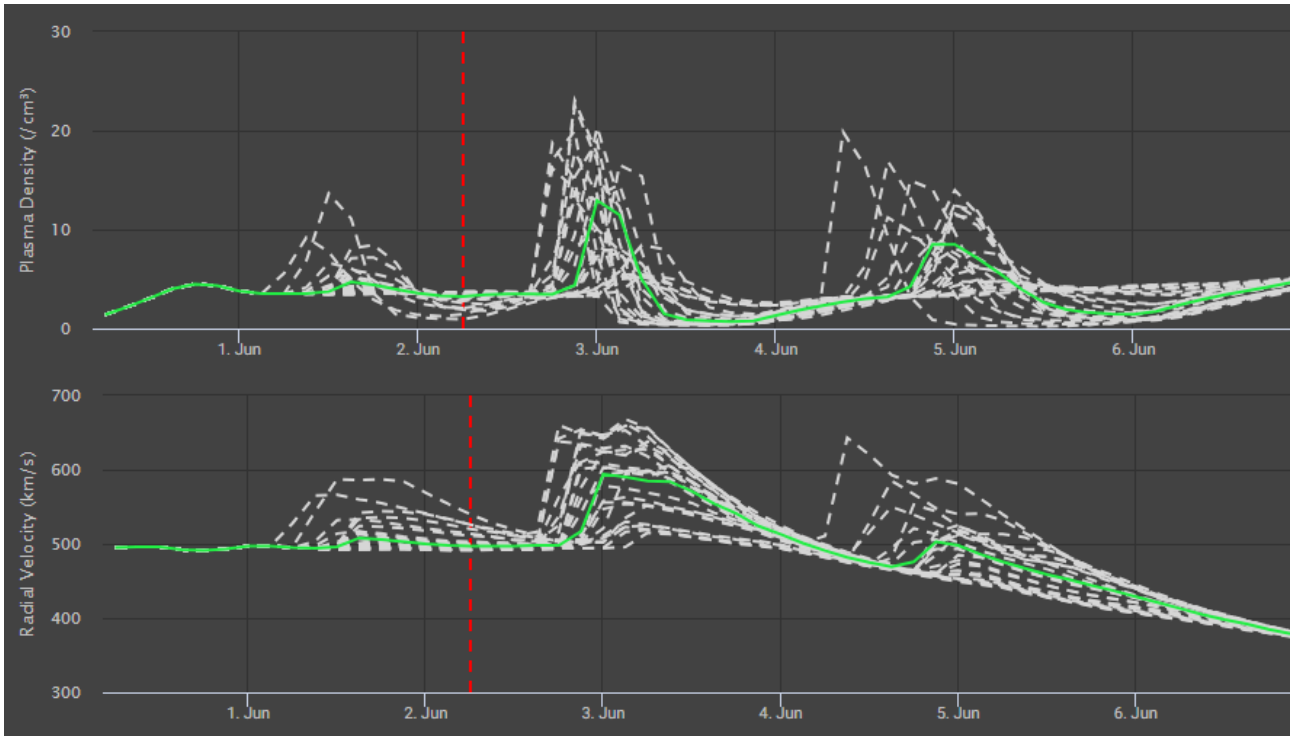
Figure 2: MOSWOC ENLIL Ensemble output showing the potential arrivals mentioned above, though note current overestimation of wind speeds lowering confidence significantly for precise timings.



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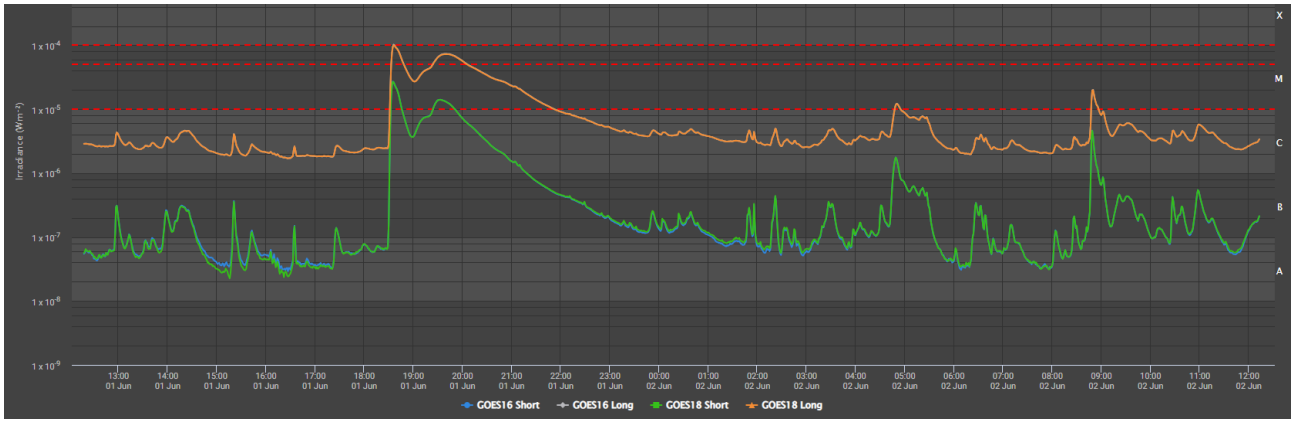
Radio Blackouts - X-Ray Flares:
Solar activity is currently High, and expected to remain Moderate to High through the period, with the potential for occasional M or X-class flares, predominately from AR3697 although this risk perhaps showing signs of trending down slowly though the period.

There are eight numbered and one unnumbered sunspot regions on the disc. The majority of the activity is associated with AR3697, which persists as a large and complex spot on the southeast disc. While somewhat reduced in size and complexity compared to the last rotation (as AR3664), this region has now produced five X-class flares since being observable on the east limb. Although recent weakening trends have continued as umbra within the main delta spot continue to fragmented somewhat, multiple small delta spot features remain present and the history of this feature suggest the potential for X-class flares remains, at least in the near term. Elsewhere on the disc, isolated M-flares are also possible, most likely from AR3691, AR3699 and AR3700.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	80	75	70	65
Very Active	R3 to R5 X Class	Yes	40	35	30	25

Figure 3: Latest GOES 16/18 X-Ray trace.



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Solar Radiation Storms - (High Energy Protons):
GOES-18 high energy proton flux is currently at background, with no response observed from the X-flares of AR3697 on 31 May and 01 Jun. This region, however, continues to have the potential for stronger flares, with an steadily improving position for any such flares to eject Earth-directed high energy protons as it transits into the western hemisphere. Despite this improving location, the confidence in the longevity of the flare risk from the region does slightly fall through the period. These two factors balance to give an overall slight chance of proton flux enhancement occurring and reaching the S1 Minor Storm threshold. Given the potential for stronger flares, it also cannot be completely ruled out that any such proton storm could exceed the strong threshold (S3 Strong radiation storm).

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	20	20	20
Very Active	**≥ S3 ***	No	5	5	5	5
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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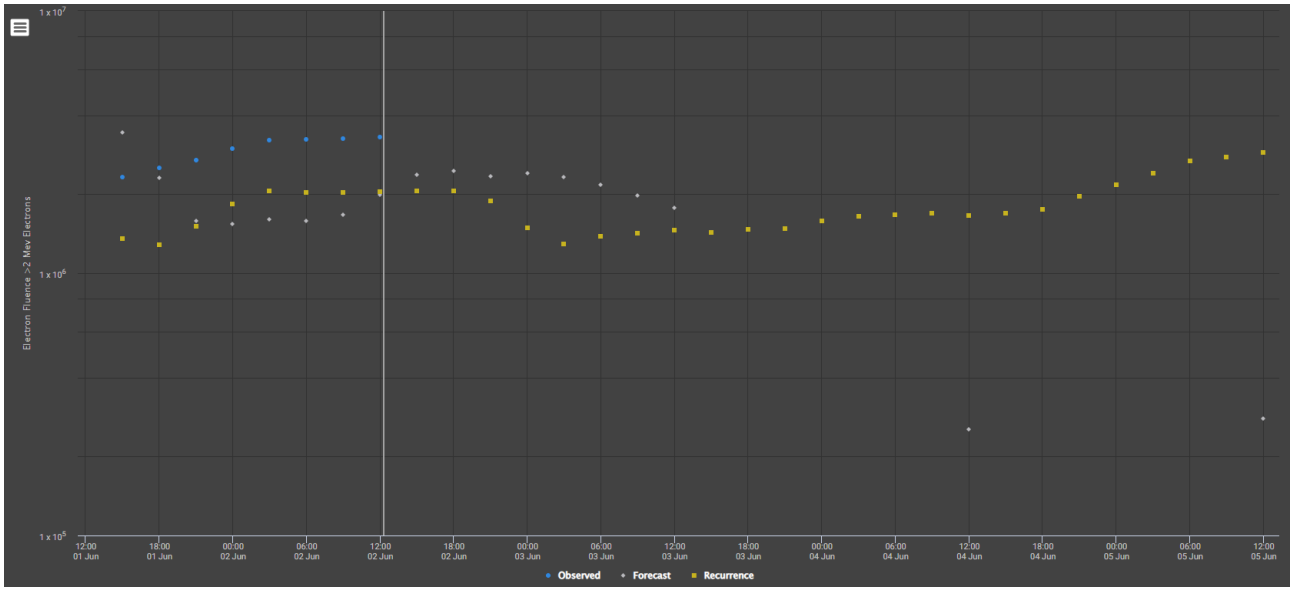
High Energy Electrons Event (≥ 2MeV):
The high energy electron flux, as observed by GOES-16, is expected to persist at mainly background, with no notable sources of potential enhancement currently anticipated. The associated 24 hour electron fluence is expected to remain well below the Active level, as supported by MOSWOC REFM, which is currently thought to be giving good guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	1
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: Latest MOSWOC REFM model output.



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